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(54) Title: BIODEGRADABLE THERMOPLASTIC COMPOSITION

(57) Abstract: A thermoplastic composition that comprises an unreacted mixture of polyethylene oxide polymer, an aliphatic polyester polymer, and a multicarboxylic acid. The thermoplastic composition is capable of being extruded into fibers that may be formed into nonwoven structures that may be used in a disposable absorbent product intended for the absorption of fluids such as body fluids.



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## BIODEGRADABLE THERMOPLASTIC COMPOSITION

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### 15 FIELD OF THE INVENTION

The present invention relates to a thermoplastic composition that comprises a unreacted mixture of polyethylene oxide, an aliphatic polyester polymer, and a multicarboxylic acid. The thermoplastic composition is capable of being extruded into  
20 fibers that may be formed into nonwoven structures that may be used in a disposable absorbent product intended for the absorption of fluids such as body fluids.

### BACKGROUND OF THE INVENTION

25 Disposable absorbent products currently find widespread use in many applications. For example, in the infant and child care areas, diapers and training pants have generally replaced reusable cloth absorbent articles. Other typical disposable absorbent products include feminine care products such as sanitary  
30 napkins or tampons, adult incontinence products, and health care products such as surgical drapes or wound dressings. A typical disposable absorbent product generally comprises a composite structure including a topsheet, a backsheet, and an absorbent structure between the topsheet and backsheet. These products  
35 usually include some type of fastening system for fitting the product onto the wearer.

Disposable absorbent products are typically subjected to one or more liquid insults, such as of water, urine, menses, or blood, during use. As such, the outer cover backsheet materials of the disposable absorbent products are typically made of liquid-insoluble and liquid impermeable materials, such as polypropylene films, that exhibit a sufficient strength and handling capability so that the disposable absorbent product retains its integrity during use by a wearer and does not allow leakage of the liquid insulting the product.

Although current disposable baby diapers and other disposable absorbent products have been generally accepted by the public, these products still have need of improvement in specific areas. For example, many disposable absorbent products can be difficult to dispose of. For example, attempts to flush many disposable absorbent products down a toilet into a sewage system typically lead to blockage of the toilet or pipes connecting the toilet to the sewage system. In particular, the outer cover materials typically used in the disposable absorbent products generally do not disintegrate or disperse when flushed down a toilet so that the disposable absorbent product cannot be disposed of in this way. If the outer cover materials are made very thin in order to reduce the overall bulk of the disposable absorbent product so as to reduce the likelihood of blockage of a toilet or a sewage pipe, then the outer cover material typically will not exhibit sufficient strength to prevent tearing or ripping as the outer cover material is subjected to the stresses of normal use by a wearer.

Furthermore, solid waste disposal is becoming an ever increasing concern throughout the world. As landfills continue to fill up, there has been an increased demand for material source reduction in disposable products, the incorporation of more recyclable and/or degradable components in disposable products, and the design of products that can be disposed of by means other than by incorporation into solid waste disposal facilities such as landfills.

As such, there is a need for new materials that may be used in disposable absorbent products that generally retain their integrity and strength during use, but after such use, the materials may be more efficiently disposed of. For example, the disposable

absorbent product may be easily and efficiently disposed of by composting. Alternatively, the disposable absorbent product may be easily and efficiently disposed of to a liquid sewage system wherein the disposable absorbent product is capable of being degraded.

Polyethylene oxide is a known material and has been used widely in a variety of applications. However, the processing of polyethylene oxide into a fiber, a film, or other extrudable or nonwoven structures has proven to be a significant challenge. This challenging task has been found to be particularly acute when trying to use polyethylene oxide in a fiber making process. Such processing difficulty is due, in part, to the fact that commercially-available polyethylene oxide typically comes in a powder form and is predominately available in high molecular weight versions, typically ranging in a weight average molecular weight from over 100,000 to 8,000,000.

Such a physical form or properties of the polyethylene oxide has been found to negatively impact the processing of the polyethylene oxide in several ways. First, any material, including polyethylene oxide, in a powder form is generally more difficult to process in terms of feeding and extrusion as compared to a material in a pelletized form, such as is typically encountered, for example, with polyolefins. Second, the high molecular weight of the polyethylene oxide typically results in significant entanglement of the polyethylene oxide polymer chains during certain processing techniques, such as extrusion. An extruder being used in such a situation will typically require a very large torque to feed the high molecular weight material through it which typically results in a pronounced "elastic-retraction" property of the molten fiber being processed which generally results in the molten fiber resisting being drawn down as it exits a spinneret attached to the extruder. These factors generally result in a very poor melt strength of the resultant fiber and make fiber spinning impracticable. Third, polyethylene oxide has a very low melting temperature, generally about 65°C, which makes the polyethylene oxide difficult to solidify during quenching and which causes process difficulties due to the stickiness of fiber prepared from the polyethylene oxide.

In addition, polyethylene oxide is generally not fully biodegradable. Finally, is polyethylene oxide generally a water soluble polymer. As such, even if one were able to prepare fibers from polyethylene oxide, such fibers would have a limited usefulness in applications in which the fibers were to be insulted with a liquid such as water, urine, blood, or menses. Thus, it would be desirable to be able to make a fiber comprising polyethylene oxide which was not instantly water soluble but instead exhibited a delayed solubility in, for example, water or other aqueous liquids.

Accordingly, there is a need for a thermoplastic composition useful as a wettable structure with improved fluid management properties. Additionally there is a need for thermoplastic composition that is biodegradable while also providing these improved fluid management properties.

#### SUMMARY OF THE INVENTION

It is therefore desired to provide a thermoplastic composition which exhibits improved processability properties and desirable solubility properties.

It is also desired to provide a thermoplastic composition which may be easily and efficiently formed into a fiber.

It is also desired to provide a thermoplastic composition which is suitable for use in preparing nonwoven structures.

It is also desired to provide a fiber or nonwoven structure that is readily degradable in the environment.

The present invention concerns a thermoplastic composition that is desirably biodegradable and yet which is easily prepared and readily processable into desired final structures, such as fibers or nonwoven structures.

One aspect of the present invention concerns a thermoplastic composition that comprises a mixture of a first component, a second component and a third component.

One embodiment of such a thermoplastic composition comprises a mixture of a polyethylene oxide, an aliphatic polyester polymer, and a multicarboxylic acid, wherein the multicarboxylic

acid has a total of carbon atoms that is less than about 30, wherein the thermoplastic composition exhibits desired properties.

In another aspect, the present invention concerns a fiber prepared from the thermoplastic composition wherein the fiber exhibits desired properties.

In another aspect, the present invention concerns a nonwoven structure comprising a fiber prepared from the thermoplastic composition.

One embodiment of such a nonwoven structure is a backsheet, topsheet or absorbent core useful in a disposable absorbent product.

In another aspect, the present invention concerns a disposable absorbent product comprising a nonwoven structure comprising a fiber prepared from the thermoplastic composition.

## DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to a thermoplastic composition which includes a first component, a second component and a third component. As used herein, the term "thermoplastic" is meant to refer to a material that softens when exposed to heat and generally returns to its original condition when cooled to room temperature.

The first component in the thermoplastic composition is a polyethylene oxide polymer. Suitable polyethylene oxide polymers are known and may be obtained, for example, from Union Carbide Corporation of Danbury, Connecticut.

The polyethylene oxide polymer suitable for use in the present invention is desirably water soluble. As used herein, a material will be considered to be water soluble when it substantially dissolves in excess water to form a solution, thereby losing its initial form and becoming essentially molecularly dispersed throughout the water solution. As a general rule, a water-soluble material will be free from a substantial degree of crosslinking, as crosslinking tends to render a material water insoluble.

As used herein, the term "water-insoluble" is meant to refer to a material that, when exposed to an excess of water, disperses but does not dissolve into the solution. As such, a water-

insoluble material generally retains its original identity or physical structure, but in a highly dispersed state and must have sufficient physical integrity to resist flow and fusion with neighboring materials.

5           It is generally desired that the polyethylene oxide polymer exhibit a weight average molecular weight that is effective for the thermoplastic composition to exhibit desirable melt strength, fiber mechanical strength, and fiber spinning properties. In general, if the weight average molecular weight of a  
10 polyethylene oxide polymer is too high, this represents that the polymer chains may become heavily entangled which may result in a thermoplastic composition comprising that polyethylene oxide polymer being difficult to process. Conversely, if the weight  
15 average molecular weight of a polyethylene oxide polymer is too low, this represents that the polymer chains are not entangled enough which may result in a thermoplastic composition comprising that polyethylene oxide polymer exhibiting a relatively weak melt strength, making high speed processing very difficult. Thus, polyethylene oxide polymers suitable for use in the present  
20 invention exhibit weight average molecular weights that are beneficially between about 100,000 to about 20,000,000, more beneficially between about 150,000 to about 10,000,000, and suitably between about 200,000 to about 8,000,000. The weight  
25 average molecular weight for polymers or polymer blends can be determined using a method as described in the Test Methods section herein.

          It is generally desired that the polyethylene oxide polymer be melt processable. It is therefore desired that the polyethylene oxide polymers used in the present invention exhibit  
30 a melt flow rate that is beneficially between about 1 gram per 10 minutes to about 600 grams per 10 minutes, suitably between about 5 grams per 10 minutes to about 200 grams per 10 minutes, and more suitably between about 10 grams per 10 minutes to about 150 grams per 10 minutes. The melt flow rate of a material may be  
35 determined according to ASTM Test Method D1238-E, incorporated in its entirety herein by reference.

          It is generally desired that the polyethylene oxide be present in the thermoplastic composition in an amount effective to

result in the thermoplastic composition exhibiting desired properties. If the polyethylene oxide is present in the thermoplastic composition in too small of an amount, the thermoplastic composition will generally exhibit poor extrusion processability properties represented, for example, by exhibiting too low of an apparent viscosity during processing at conditions, for example, of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> as well as being too insoluble in, for example, water or other aqueous liquids, thereby limiting the use of such fibers in applications such as disposable absorbent products where the disposable absorbent product is desired to be flushable. In contrast, if the polyethylene oxide is present in the thermoplastic composition in too large of an amount, the thermoplastic composition will generally exhibit poor extrusion processability properties represented, for example, by exhibiting too high of an apparent viscosity during processing at conditions, for example, of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> as well as being too quickly soluble in, for example, water or other aqueous liquids, thereby limiting the use of such fibers in applications such as disposable absorbent products.

Therefore, the polyethylene oxide will be present in the thermoplastic composition of the present invention in a weight amount that is beneficially between about 10 weight percent to about 70 weight percent, more beneficially between about 30 weight percent to about 70 weight percent, and suitably between about 35 weight percent to about 65 weight percent, wherein all weight percents are based on the total weight amount of the polyethylene oxide, the aliphatic polyester polymer and the multicarboxylic acid present in the thermoplastic composition.

The second component in the thermoplastic composition is an aliphatic polyester polymer. The aliphatic polyester polymer is preferably selected from the group consisting of polylactides, a polybutylene succinate polymer, a polybutylene succinate-co-adipate polymer, a polycaprolactone polymer, a mixture of such polymers, or a copolymer of such polymers.

A polybutylene succinate polymer, such as polybutylene succinate or polybutylene succinate adipate, is generally prepared by the condensation polymerization of a glycol and a dicarboxylic acid or an acid anhydride thereof. A



polybutylene succinate polymer may either be a linear polymer or a long-chain branched polymer. A long-chain branched polybutylene succinate polymer is generally prepared by using an additional polyfunctional component selected from the group consisting of trifunctional or tetrafunctional polyols, oxycarboxylic acids, and polybasic carboxylic acids. Polybutylene succinate polymers are known in the art and are described, for example, in European Patent Application 0 569 153 A2 to Showa Highpolymer Co., Ltd., Tokyo, Japan.

A polybutylene succinate-co-adipate polymer is generally prepared by the polymerization of at least one alkyl glycol and more than one aliphatic multifunctional acid. Polybutylene succinate-co-adipate polymers are also known in the art.

Examples of polybutylene succinate polymers and polybutylene succinate-co-adipate polymers that are suitable for use in the present invention include a variety of polybutylene succinate polymers and polybutylene succinate-co-adipate polymers that are available from Showa Highpolymer Co., Ltd., Tokyo, Japan, under the designation BIONOLLE™ 1020 polybutylene succinate polymer or BIONOLLE™ 3020 polybutylene succinate-co-adipate polymer, which are essentially linear polymers. These materials are known to be substantially biodegradable.

A polycaprolactone polymer is generally prepared by the polymerization of  $\epsilon$ -caprolactone. Examples of polycaprolactone polymers that are suitable for use in the present invention include a variety of polycaprolactone polymers that are available from Union Carbide Corporation, Somerset, New Jersey, under the designation TONE™ Polymer P767E and TONE™ Polymer P787 polycaprolactone polymers. These materials are known to be substantially biodegradable.

It is generally desired that the aliphatic polyester polymer selected from the group consisting of a polybutylene succinate polymer, a polybutylene succinate-co-adipate polymer, a polycaprolactone polymer, a mixture of such polymers, or a copolymer of such polymers be present in the thermoplastic composition in an amount effective to result in the thermoplastic

composition exhibiting desired properties. The aliphatic polyester polymer will be present in the thermoplastic composition in a weight amount that is greater than 10 but less than 70 weight percent, beneficially between about 20 weight percent to less than 70 weight percent, more beneficially between about 25 weight percent to about 65 weight percent, suitably between about 30 weight percent to about 60 weight percent, more suitably between about 35 weight percent to about 55 weight percent, and most suitably between about 40 weight percent to about 50 weight percent, wherein all weight percents are based on the total weight amount of the aliphatic polyester polymer, the multicarboxylic acid, and the wetting agent present in the thermoplastic composition.

It is generally desired that the aliphatic polyester polymer exhibit a weight average molecular weight that is effective for the thermoplastic composition to exhibit desirable melt strength, fiber mechanical strength, and fiber spinning properties. In general, if the weight average molecular weight of an aliphatic polyester polymer is too high, this represents that the polymer chains are heavily entangled which may result in a thermoplastic composition comprising that aliphatic polyester polymer being difficult to process. Conversely, if the weight average molecular weight of an aliphatic polyester polymer is too low, this represents that the polymer chains are not entangled enough which may result in a thermoplastic composition comprising that aliphatic polyester polymer exhibiting a relatively weak melt strength, making high speed processing very difficult. Thus, aliphatic polyester polymers suitable for use in the present invention exhibit weight average molecular weights that are beneficially between about 10,000 to about 2,000,000, more beneficially between about 50,000 to about 400,000, and suitably between about 100,000 to about 300,000. The weight average molecular weight for polymers or polymer blends can be determined by methods known to those skilled in the art.

It is also desired that the aliphatic polyester polymer exhibit a polydispersity index value that is effective for the thermoplastic composition to exhibit desirable melt strength, fiber mechanical strength, and fiber spinning properties. As used herein,

“polydispersity index” is meant to represent the value obtained by dividing the weight average molecular weight of a polymer by the number average molecular weight of the polymer. The number average molecular weight for polymers or polymer blends can be determined by methods known to those skilled in the art. In general, if the polydispersity index value of an aliphatic polyester polymer is too high, a thermoplastic composition comprising that aliphatic polyester polymer may be difficult to process due to inconsistent processing properties caused by polymer segments comprising low molecular weight polymers that have lower melt strength properties during spinning. Thus, it is desired that the aliphatic polyester polymer exhibits a polydispersity index value that is beneficially between about 1 to about 15, more beneficially between about 1 to about 4, and suitably between about 1 to about 3.

It is generally desired that the aliphatic polyester polymer be melt processable. It is therefore desired that the aliphatic polyester polymer exhibit a melt flow rate that is beneficially between about 1 gram per 10 minutes to about 200 grams per 10 minutes, suitably between about 10 grams per 10 minutes to about 100 grams per 10 minutes, and more suitably between about 20 grams per 10 minutes to about 40 grams per 10 minutes. The melt flow rate of a material may be determined, for example, according to ASTM Test Method D1238-E, incorporated in its entirety herein by reference.

The third component in the thermoplastic composition is a multicarboxylic acid. A multicarboxylic acid is any acid that comprises two or more carboxylic acid groups. Suitable for use in the present invention are dicarboxylic acids, which comprise two carboxylic acid groups. It is generally desired that the multicarboxylic acid have a total number of carbons that is not too large because then the multicarboxylic acid may negatively interfere with the processing of the thermoplastic composition. It is therefore desired that the multicarboxylic acid have a total of carbon atoms that is beneficially less than about 30, more beneficially between about 3 to about 30, suitably between about 4 to about 20, and more suitably between about 5 to about 10. Suitable multicarboxylic acids include, but are not limited to,

malonic acid, citric acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, and mixtures thereof.

5 The multicarboxylic acids suitable for use in the present invention are generally water soluble but generally exhibit a solubility that is relatively slower than that exhibited by polyethylene oxide. As such, the adding of the multicarboxylic acid to a polyethylene oxide generally reduces or slows down the water-solubility of the overall mixture.

10 It is generally desired that the multicarboxylic acid be present in the thermoplastic composition in an amount effective to result in the thermoplastic composition exhibiting desired properties. If the multicarboxylic acid is present in the thermoplastic composition in too small of an amount, the  
15 thermoplastic composition will generally exhibit poor extrusion processability properties represented, for example, by exhibiting too high of an apparent viscosity during processing at conditions, for example, of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> as well as being too quickly soluble in, for example,  
20 water or other aqueous liquids, thereby limiting the use of such fibers in applications such as disposable absorbent products. In contrast, if the polyethylene oxide is present in the thermoplastic composition in too small of an amount, the thermoplastic composition will generally exhibit poor extrusion processability  
25 properties represented, for example, by exhibiting too low of an apparent viscosity during processing at conditions, for example, of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> as well as being too insoluble in, for example, water or other aqueous liquids, thereby limiting the use of such fibers in applications such as  
30 disposable absorbent products where the disposable absorbent product is desired to be flushable.

Therefore, the multicarboxylic acid will be present in the thermoplastic composition in a weight amount that is  
35 beneficially between about 10 weight percent to about 30 weight percent, more beneficially between about 10 weight percent to about 25 weight percent, and suitably between about 15 weight percent to about 20 weight percent, wherein all weight percents are based on the total weight amount of the polyethylene oxide

polymer, the aliphatic polyester polymer and the multicarboxylic acid present in the thermoplastic composition.

5 In the present invention, it is generally desired that the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid be biodegradable. As a result, the thermoplastic composition comprising the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid, either in the form of a fiber or in the form of a nonwoven structure, will be degradable when disposed of to the environment and exposed to air and/or water. As used herein, "biodegradable" is meant to represent that a material degrades from the action of naturally occurring microorganisms such as bacteria, fungi, and algae.

15 In the present invention, it is also desired that the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid be compostable. As a result, the thermoplastic composition comprising the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid, either in the form of a fiber or in the form of a nonwoven structure, will be compostable when disposed of to the environment and exposed to air and/or water. As used herein, "compostable" is meant to represent that a material is capable of undergoing biological decomposition in a compost site such that the material is not visually distinguishable and breaks down into carbon dioxide, water, inorganic compounds, and biomass, at a rate consistent with known compostable materials.

25 While the principal components of the thermoplastic composition of the present invention have been described in the foregoing, such thermoplastic composition is not limited thereto and can include other components not adversely effecting the the desired properties of the thermoplastic composition. Exemplary materials which could be used as additional components would include, without limitation, pigments, antioxidants, stabilizers, surfactants, waxes, flow promoters, solid solvents, plasticizers, nucleating agents, particulates, and materials added to enhance processability of the thermoplastic composition. If such additional components are included in a thermoplastic composition, it is generally desired that such additional components be used in an

amount that is beneficially less than about 5 weight percent, more beneficially less than about 3 weight percent, and suitably less than about 1 weight percent, wherein all weight percents are based on the total weight amount of the polyethylene oxide polymer, the aliphatic polyester polymer, the multicarboxylic acid, and the additional components present in the thermoplastic composition.

The thermoplastic composition of the present invention is simply an unreacted mixture of the polyethylene oxide polymer, the aliphatic polyester polymer, the multicarboxylic acid, and, optionally, any additional components. In order to achieve the desired properties for the thermoplastic composition of the present invention, it has been discovered that it is important that the polyethylene oxide polymer, the aliphatic polyester polymer, and the multicarboxylic acid remain substantially unreacted with each other such that a copolymer comprising each of the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid is not formed. As such, each of the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid remain distinct components of the thermoplastic composition. In order to determine if the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid remain essentially unreacted, it is possible to use techniques, such as nuclear magnetic resonance and infrared analysis, to evaluate the chemical characteristics of the final thermoplastic composition.

Each of the polyethylene oxide polymer, the aliphatic polyester polymer, and the multicarboxylic acid will generally form separate regions or domains within a prepared mixture forming the thermoplastic composition. However, depending on the relative amounts that are used of each of the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid, an essentially continuous phase may be formed from the material that is present in the thermoplastic composition in a relatively greater amount. In contrast, the material that is present in the thermoplastic composition in a relatively lesser amount may form an essentially discontinuous phase, forming separate regions or domains within the continuous phase of the more prevalent material wherein the more prevalent material continuous phase

substantially encases the less prevalent material within its structure. As used herein, the term "encase", and related terms, are intended to mean that the more prevalent material continuous phase substantially encloses or surrounds the less prevalent material's separate regions or domains.

In the thermoplastic composition of the present invention, the multicarboxylic acid is believed to perform at least one important function. When the thermoplastic composition is in a molten state, the multicarboxylic acid is believed to function as a process lubricant or plasticizer that facilitates the processing of the thermoplastic composition while increasing the flexibility and toughness of a final product, such as a fiber or a nonwoven structure, through internal modification of the polyethylene oxide polymer. While not intending to be bound hereby, it is believed that the multicarboxylic acid replaces the secondary valence bonds holding together the aliphatic polyester polymer chains and the polyethylene oxide polymer chains with multicarboxylic acid-to-aliphatic polyester polymer valence bonds and multicarboxylic acid-to-polyethylene oxide polymer valence bonds, respectively, thus facilitating the movement of the polymer chain segments. This effect is evidenced, for example, in that a generally lower extrusion temperature may be used to process the thermoplastic composition comprising the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid as compared to the processing of polyethylene oxide polymer or aliphatic polyester polymer alone. With this effect, the torque needed to turn an extruder is generally dramatically reduced as compared with the processing of polyethylene oxide polymer or aliphatic polyester polymer alone.

In one embodiment of the present invention, after dry mixing together the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid to form a thermoplastic composition dry mixture, such thermoplastic composition dry mixture is beneficially agitated, stirred, or otherwise blended to effectively uniformly mix the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid such that an essentially homogeneous dry mixture is formed. The dry mixture may then be melt blended in,

for example, an extruder to effectively uniformly mix the polyethylene oxide polymer, the aliphatic polyester polymer and the multicarboxylic acid such that an essentially homogeneous melted mixture is formed. The essentially homogeneous melted mixture may then be cooled and pelletized. Alternatively, the three components may be fed directly into a mixer, such as an extruder, for mixing. Alternatively, the essentially homogeneous melted mixture may be sent directly to a spin pack or other equipment for forming fibers or a nonwoven structure. Other methods of mixing together the components of the present invention are also possible and will be easily recognized by one skilled in the art.

The process of cooling the extruded thermoplastic composition to ambient temperature is usually achieved by blowing ambient or sub-ambient temperature air over the extruded polymer. It can be referred to as quenching or super-cooling because the change in temperature is usually greater than 100°C and most often greater than 150°C over a relatively short time frame (seconds).

It is generally desired that the melting or softening temperatures of the thermoplastic composition be within a range that is typically encountered in most process applications. As such, it is generally desired that the melting or softening temperatures of the thermoplastic composition beneficially be between about 25°C to about 350°C, more beneficially be between about 50°C to about 300°C, and suitably be between about 60°C to about 200°C.

The thermoplastic composition of the present invention has been found to generally exhibit improved processability properties as compared to a thermoplastic composition comprising only the polyethylene oxide polymer and none of the aliphatic polyester polymer or the multicarboxylic acid. As used herein, the improved processability of a thermoplastic composition is measured as a decline in the apparent viscosity of the thermoplastic composition at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup>, typical industrial extrusion processing conditions. If the thermoplastic composition exhibits an apparent viscosity that is too high, the thermoplastic composition will generally be very difficult to process. In contrast, if the thermoplastic composition exhibits an apparent viscosity that



is too low, the thermoplastic composition will generally result in an extruded fiber that has very poor tensile strength.

Therefore, it is generally desired that the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is beneficially between about 5 Pascal seconds (Pa.s) to about 120 Pascal seconds, more beneficially between about 10 Pascal seconds to about 110 Pascal seconds, suitably between about 15 Pascal seconds to about 100 Pascal seconds, more suitably between about 20 Pascal seconds to about 90 Pascal seconds, and most suitably between about 25 Pascal seconds to about 80 Pascal seconds. The method by which the Apparent Viscosity value is determined is set forth below in connection with the examples.

As used herein, the term "fiber" or "fibrous" is meant to refer to a material wherein the length to diameter ratio of such material is greater than about 10. Conversely, a "nonfiber" or "nonfibrous" material is meant to refer to a material wherein the length to diameter ratio of such material is about 10 or less.

Methods for making fibers are well known and need not be described here in detail. To form a fiber, generally, a thermoplastic composition is extruded and fed to a distribution system where the thermoplastic composition is introduced into a spinneret plate. The spun fiber is then cooled, solidified, and drawn, generally by a mechanical rolls system, to an intermediate filament diameter and collected. Subsequently, the fiber may be "cold drawn" at a temperature below its softening temperature, to the desired finished fiber diameter and is crimped/texturized and cut into a desirable fiber length. Fibers can be cut into relatively short lengths, such as staple fibers which generally have lengths in the range of about 25 to about 50 millimeters and short-cut fibers which are even shorter and generally have lengths less than about 18 millimeters.

Typical conditions for thermally processing the thermoplastic composition include using a shear rate that is beneficially between about 100 seconds<sup>-1</sup> to about 50000 seconds<sup>-1</sup>, more beneficially between about 500 seconds<sup>-1</sup> to about 5000 seconds<sup>-1</sup>, suitably between about 1000 seconds<sup>-1</sup> to about

3000 seconds<sup>-1</sup>, and most suitably at about 1000 seconds<sup>-1</sup>. Typical conditions for thermally processing the components also include using a temperature that is beneficially between about 100°C to about 500°C, more beneficially between about 150°C to about 300°C, suitably between about 175°C to about 250°C, and suitably about 190°C.

The thermoplastic composition of the present invention is suited for preparing fibers or nonwoven structures that may be used in disposable products including disposable absorbent products such as diapers, adult incontinent products, and bed pads; in catamenial devices such as sanitary napkins, and tampons; and other absorbent products such as wipes, bibs, wound dressings, and surgical capes or drapes. Accordingly, in another aspect, the present invention relates to a disposable absorbent product comprising the fibers prepared from the thermoplastic composition of the present invention.

When used in a disposable absorbent product, it is generally desired that a fiber prepared from the thermoplastic composition of the present invention be hydrophilic. As used herein, the term "hydrophilic" refers to a material having a contact angle of water in air of less than 90 degrees. In contrast, as used herein, the term "hydrophobic" refers to a material having a contact angle of water in air of at least 90 degrees. The general subject of contact angles and the measurement thereof is well known in the art as, for example, in Robert J. Good and Robert J. Stromberg, Ed., in "Surface and Colloid Science - Experimental Methods", Vol. II, (Plenum Press, 1979).

In one embodiment of the present invention, the thermoplastic composition is formed into a multicomponent fiber. For purposes of illustration only, the present invention will generally be described in terms of a multicomponent fiber comprising only three components. However, it should be understood that the scope of the present invention is meant to include fibers with three or more components. In one embodiment, the thermoplastic composition of the present invention may be used to form the sheath of a multicomponent fiber while a polyolefin, such as polypropylene or polyethylene, or a polyester is used to form the core. Suitable structural geometries for

multicomponent fibers include pie shape or side by side configurations.

When the thermoplastic composition of the present invention is formed into a multicomponent fiber, an exposed surface on at least a portion of the multicomponent fiber will typically be formed from the more prevalent material present in the multicomponent fiber. Such an exposed surface on at least a portion of the multicomponent fiber which will generally permit thermal bonding of the multicomponent fiber to other fibers which may be the same or different from the multicomponent fiber of the present invention. As a result, the multicomponent fiber can then be used to form thermally bonded fibrous nonwoven structures such as a nonwoven web.

In one embodiment of the present invention, the thermoplastic composition is formed into a fibrous matrix for incorporation into a disposable absorbent product. A fibrous matrix may take the form of, for example, a fibrous nonwoven web. Fibrous nonwoven webs may be made completely from fibers prepared from the thermoplastic composition of the present invention or they may be blended with other fibers. The length of the fibers used may depend on the particular end use contemplated. Where the fibers are to be degraded in water as, for example, in a toilet, it is advantageous if the lengths are maintained at or below about 15 millimeters.

The thermoplastic composition can also be used as a coated or co-extruded component of a flushable film for applications in composite cloth-like outer covers for flushable diapers, or as a baffle barrier film for feminine care napkins and adult incontinence products. These thermoplastic composition can also be used in cast film or blown film applications.

In one embodiment of the present invention, a disposable absorbent product is provided, which disposable absorbent product comprises a liquid-permeable topsheet, a backsheet attached to the liquid-permeable topsheet, and an absorbent structure positioned between the liquid-permeable topsheet and the backsheet, wherein the backsheet, topsheet and/or the absorbent structure comprises fibers prepared from the thermoplastic composition of the present invention.

Absorbent products and structures according to all aspects of the present invention are generally subjected, during use, to multiple insults of a body liquid. Accordingly, the absorbent products and structures are desirably capable of absorbing multiple insults of body liquids in quantities to which the absorbent products and structures will be exposed during use. The insults are generally separated from one another by a period of time.

## TEST PROCEDURES

### *Apparent Viscosity*

A capillary rheometer, under the designation Göttfert Rheograph 2003 capillary rheometer, which was used in combination with WinRHEO (version 2.31) analysis software, both available from Göttfert Company of Rock Hill, South Carolina, was used to evaluate the apparent viscosity rheological properties of material samples. The capillary rheometer setup included a 2000 bar pressure transducer and a 30 mm length/30 mm active length/1 mm diameter/0 mm height/180° run in angle, round hole capillary die.

Once the instrument is warmed up and the pressure transducer is calibrated, the material sample is loaded incrementally into the column, packing resin into the column with a ramrod each time to ensure a consistent melt during testing. After material sample loading, a 2 minute melt time precedes each test to allow the material sample to completely melt at the test temperature. The capillary rheometer takes data points automatically and determines the apparent viscosity (in Pascal·second) at 7 apparent shear rates (in  $\text{second}^{-1}$ ): 50, 100, 200, 500, 1000, 2000, and 5000. When examining the resultant curve it is important that the curve be relatively smooth. If there are significant deviations from a general curve from one point to another, possibly due to air in the column, the test run should be repeated to confirm the results.

The resultant rheology curve of apparent shear rate versus apparent viscosity gives an indication of how the material sample will run at that temperature in an extrusion process. The apparent viscosity value at a shear rate of about  $1000 \text{ second}^{-1}$  and

a temperature of about 190°C is of specific interest because these are the typical conditions found in commercial fiber spinning extruders.

5      *Weight Average Molecular Weight*

A gas permeation chromatography (GPC) method may be used to determine the weight average molecular weight of polyethylene oxide samples.

10      A differential refractometer, available from Viscotek Corporation under the designation Knauer Differential Refractometer with a Viscotek Differential Viscometer, Model 100, is set up with two linear, 120 Angstrom Waters Ultrahydrogel gas permeation chromatography columns having a flow rate of about 1.0 ml/minute and an injection volume of 100 microliters.  
15      The mobile phase is a 0.05M sodium nitrate aqueous solution. The mobile phase is filtered with a 0.45 micron filter and degassed using a vacuum and an ultrasound bath. Polyethylene oxide standards are obtained having narrow molecular weight distributions with known peak average molecular weight and  
20      intrinsic viscosity values.

Samples of both the standard polyethylene oxides and experimental polyethylene oxide materials are prepared by dissolving about 10 to 25 mg (weighed to the nearest 0.0001g) of a polyethylene oxide material into about 20.0 ml of the mobile phase  
25      solution in a clear borosilicate scintillation vial. Each standard and experimental sample is chromatographed three times in order to ensure reproducibility of results and to guard against unexpected instrumental upsets. The data is collected and calculated using Unical GPC software, version 4.03, available from Viscotek Corporation of Houston, Texas. The software manual describes in  
30      detail all the formulas, algorithms and convolute integrals used for the calculations. For each sample, the weight average molecular weight is obtain.

To confirm that the instrument is operating correctly, a  
35      number of checks are performed. The differential refractometer should have a reading of 3.0 millivolts on the detector output, the differential transducers on the viscometer should be set close to zero, and system back pressure should have a reading below 1000

psi. A monodisperse low molecular weight standard peak should be symmetrical and the total number of plates should be above 16,000 plates/bank.

5      *Water Dispersability/Dissolution/Uptake of a Fiber*

10      The water dispersibility/dissolution evaluation of a fiber sample was done by immersing a fiber of about 300 microns in diameter and of a length of about 5 centimeters into a 100 milliliter beaker containing tap water at about 18°C and examining the degree of the fiber's disintegration and dissolution over time. For a sample that dissolves or disintegrates into pieces smaller than 1 millimeter within 10 minutes of the beginning of the testing, the tested sample was defined as an "Instant" dispersibility.

15      The water uptake testing was performed on a Cahn DCA-322 microbalance with WinDCA version 1.02. A single freefall fiber of approximately 3cm in length was fastened to a wire hanger so that 1.5cm hangs past the end of the wire. The fiber diameter was determined with an optical microscope. The sample was then hung in the microbalance and immersed into a 100 milliliter beaker full of tap water. The analysis software determines water uptake of fiber by using force(mg) over time (minutes). The greater the force reading the more water the fiber was absorbing.

25      **EXAMPLES**

30      A ZSK-30 co-rotating, twin screw extruder (manufactured by Werner & Pfleiderer) with 14 barrels and 1338 mm total processing length was used. All three components were fed into the throat of the extruder via a large hopper that was fed from three gravometric feeders (manufactured by K-tron corp). The die at the end of extruder has 4 openings of 3mm in diameter, which are separated by 7 mm. The polymer blend was extruded onto an air-cooling belt and then pelletized.

35      The compounding experiments were executed on the ZSK-30 extruder as follows: the extruder barrel temperatures were set at 145° C, 155° C, 160° C, 160° C, 160° C, 160° C, 160° C, zones 1 through 7. The screw speed was set at 200 rpms. The selected materials were introduced into the extruder throat through

a large hopper that was fed from three gravometric feeders at a given rate that totaled 30#/hr. The three ratios produced were a 60:20:20, 40:40:20 and a 20:60:20 blend consisting of polyethylene oxide-polycaprolactone-adipic acid and polyethylene oxide-bioblend-adipic acid. The compounded blends were then extruded onto an air-cooled belt and then pelletized. The compounding conditions were monitored during the extrusion process: barrel temperatures, gravometric feed rates, screw speed, % torque, actual barrel temperatures, melt temperature, pressure at die and vacuum.

**Table 1: Material specifications**

Materials	T <sub>m</sub>	M <sub>w</sub>	Manufacturer
WRSN-80 (PEO)	64°C	200,000	Union Carbide
Polyvinyl alcohol (PVOH)	195°C	N/A	DuPont
Polycaprolactone	60°C	60,000	Union Carbide
Bionolle 1020	114°C	40,000 -1,000,000	Showa Highpolymer Co.
Bionolle 3020	96°C	40,000 -1,000,000	Showa Highpolymer Co.
Bioblend	104°C	40,000 -1,000,000	Showa Highpolymer Co.
Adipic acid	152°C	N/A	Spectrum Chemical

After completing the compounding of different polymer ratios and blends, the polymer blends and the comparative polymers were converted into fibers, respectively. Converting the resulting blends into fibers was conducted on an in-house fiber spinning line. The spinning line consisted of a 3/4" diameter 24:1 l:d (length:diameter) extruder with 3 heating zones which feeds into a spin pump, through a 3/4" Koch SMX static mixer unit and then into the spinning head, from which the fibers are spun through 15 holes of 20 mil in diameter. Freefall fibers were produced from the fiber spinning line in order to perform a water uptake test on the fiber.

After completing the compounding of different polymer ratios and blends, the polymer blends were converted into

a meltblown fiber structure. Converting the resulting blends into this meltblown fiber structure was conducted on an in-house meltblown fiber unit. The meltblown fiber line consists of a 3/4" single screw extruder (manufactured by Killion, Inc.) with 3 heated zones which fed the melted polymer blend into a heated transfer hose which fed the material into a 12" meltblown die. The meltblown fibers were then blown onto a forming wire that had a vacuum box under it. Processing conditions for meltblown fiber unit are shown below in Table 2.

**Table 2**  
**Processing conditions for producing meltblown structures**

**PEO/Tone/Adipic system**

Blend ratio	Z-1	Z-2	Z-3	Hose	Die	Air (temp, psi)	RPM	Comments
20/60/20	100F	220F	250F	275F	275F	350F, 28 psi	25	Fine fibers, white
40/40/20	80F	250F	280F	290F	290F	350F, 28 psi	25	Fine fibers, off-yellow
60/20/20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

**PEO/Bioblend/Adipic system**

Blend ratio	Z-1	Z-2	Z-3	Hose	Die	Air (temp, psi)	RPM	Comments
20/60/20	80F	250F	280F	325F	325F	430F, 30 psi	25	Fine fibers, white
40/40/20	100F	250F	280F	290F	325F	430F, 30 psi	25	Fine fibers, off-yellow
60/20/20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

The utilities of the above invention are summarized in Table 3.



Table 3

Sample	Wt% PEO	Wt% PVOH	Wt% Biobind B1020- B3020 (50:50)	Wt% Polycap- rolactone	Wt% Adipic Acid	Apparent Viscosity (Pa·s) at 190°C, 1000s <sup>-1</sup>	Fiber Processability	Water Responsive- ness	Water Uptake (force mg)	Biodegradability **
1*	100%				0%	375	Poor, cannot be drawn into fiber, poor melt strength	Instant dispersion	0	N/A
2*		100%			0%	750	Poor, cannot be drawn into fiber, poor melt strength	Instant dispersion	0	N/A
3*			100%		0%	156	Good, can be drawn into fiber, good melt strength	No effect	0	Biodegradable
4*				100%	0%	121	Good, can be drawn into fiber, good melt strength	No effect	0	Biodegradable
5	60%		20%		20%	87	Good, can be drawn into fiber, good melt strength	Water absorbs into fibers, no dispersion	7.96	40% improvement
6	40%		40%		20%	37	Good, can be drawn into fiber, good melt strength	Water absorbs into fibers, no dispersion	1.54	60% improvement
7	20%		60%		20%	20	Good, can be drawn into fiber, good melt strength	Water absorbs into fibers, no dispersion	0.67	80% improvement

8	60%		20%	20%	98	Good, can be drawn into fiber, good melt strength	Water absorbs into fibers, no dispersion	5.47	40% improvement
9	40%		40%	20%	71	Good, can be drawn into fiber, good melt strength	Water absorbs into fibers, no dispersion	0.57	60% improvement
10	20%		60%	20%	37	Good, can be drawn into fiber, good melt strength	Water absorbs into fibers, no dispersion	0.53	80% improvement

\* Samples are not examples of this invention.

\*\* Biodegradability improvement calculated based upon Sample 1.

5           Those skilled in the art will recognize that the present invention is capable of many modifications and variations without departing from the scope thereof. Accordingly, the detailed description and examples set forth above are meant to be illustrative only and are not intended to limit, in any manner, the scope of the invention as set forth in the appended claims.

## CLAIMS

What is claimed is:

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1. A thermoplastic composition comprising a mixture of:

10 a) a polyethylene oxide polymer having a weight average molecular weight that is between about 100,000 to about 20,000,000, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 70 weight percent;

15 b) an aliphatic polyester polymer, wherein the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 70 weight percent; and

20 c) a multicarboxylic acid having a total of carbon atoms that is less than about 30, wherein the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 30 weight percent, wherein all weight percents are based on the total weight amount of the polyethylene oxide, the aliphatic polyester polymer, and the multicarboxylic acid present in the thermoplastic composition;

25 wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 5 to about 120 Pascal seconds.

30 2. The thermoplastic composition of Claim 1, wherein the polyethylene oxide polymer has a weight average molecular weight that is between about 150,000 to about 10,000,000.

3. The thermoplastic composition of Claim 1, wherein the multicarboxylic acid has a total of carbon atoms that is between about 3 to about 30.

35 4. The thermoplastic composition of Claim 1, wherein the multicarboxylic acid is selected from the group consisting of malonic acid, citric acid, succinic acid, glutaric acid, adipic acid,

pimelic acid, suberic acid, azelaic acid, sebacic acid, and mixtures thereof.

5           5.           The thermoplastic composition of Claim 1, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 25 weight percent.

15           6.           The thermoplastic composition of Claim 5, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 30 weight percent to about 50 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 30 weight percent to about 50 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 15 weight percent to about 20 weight percent.

25           7.           The thermoplastic composition of Claim 1, wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 10 Pascal seconds to about 110 Pascal seconds.

30           8.           The thermoplastic composition of Claim 7, wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 15 Pascal seconds to about 100 Pascal seconds.

35           9.           The thermoplastic composition of Claim 1, wherein the polyethylene oxide polymer has a weight average molecular weight that is between about 150,000 to about 10,000,000 and the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight

percent to about 60 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 25 weight percent and is selected from the group consisting of malonic acid, citric acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, and mixtures thereof, and the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 10 Pascal seconds to about 110 Pascal seconds.

10. The thermoplastic composition of Claim 1, wherein the aliphatic polyester polymer is selected from the group consisting of polylactides, a polybutylene succinate polymer, a polybutylene succinate-co-adipate polymer, a polycaprolactone polymer, a mixture of such polymers, or a copolymer of such polymers.

11. A fiber prepared from a thermoplastic composition, the thermoplastic composition comprising a mixture of:

a) a polyethylene oxide polymer having a weight average molecular weight that is between about 100,000 to about 20,000,000, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 70 weight percent;

b) an aliphatic polyester polymer, wherein the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 70 weight percent; and

c) a multicarboxylic acid having a total of carbon atoms that is less than about 30, wherein the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 30 weight percent, wherein all weight percents are based on the total weight amount of the polyethylene oxide, the aliphatic polyester polymer, and the multicarboxylic acid present in the thermoplastic composition;

wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 5 to about 120 Pascal seconds.

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12. The fiber of Claim 11, wherein the polyethylene oxide polymer has a weight average molecular weight that is between about 150,000 to about 10,000,000.

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13. The fiber of Claim 11, wherein the multicarboxylic acid has a total of carbon atoms that is between about 3 to about 30.

15

14. The fiber of Claim 11, wherein the multicarboxylic acid is selected from the group consisting of malonic acid, citric acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, and mixtures thereof.

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15. The fiber of Claim 11, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 25 weight percent.

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16. The fiber of Claim 15, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 30 weight percent to about 50 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 30 weight percent to about 50 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 15 weight percent to about 20 weight percent.

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17. The fiber of Claim 11, wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature

of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 10 Pascal seconds to about 110 Pascal seconds.

18. The fiber of Claim 17, wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 15 Pascal seconds to about 100 Pascal seconds.

19. The fiber of Claim 11, wherein the polyethylene oxide polymer has a weight average molecular weight that is between about 150,000 to about 10,000,000 and the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 25 weight percent and is selected from the group consisting of malonic acid, citric acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, and mixtures thereof, and the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 10 Pascal seconds to about 110 Pascal seconds.

20. The fiber of Claim 11, wherein the aliphatic polyester polymer is selected from the group consisting of polylactides, a polybutylene succinate polymer, a polybutylene succinate-co-adipate polymer, a polycaprolactone polymer, a mixture of such polymers, or a copolymer of such polymers.

21. A disposable absorbent product comprising a liquid-permeable topsheet, a backsheet attached to the liquid-permeable topsheet, and an absorbent structure positioned between the liquid-permeable topsheet and the backsheet, wherein at least one of the backsheet, the topsheet or the absorbent structure comprises fibers prepared from a thermoplastic composition comprising a mixture of:



a) a polyethylene oxide polymer having a weight average molecular weight that is between about 100,000 to about 20,000,000, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 70 weight percent;

b) an aliphatic polyester polymer, wherein the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 70 weight percent; and

c) a multicarboxylic acid having a total of carbon atoms that is less than about 30, wherein the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 30 weight percent, wherein all weight percents are based on the total weight amount of the polyethylene oxide, the aliphatic polyester polymer, and the multicarboxylic acid present in the thermoplastic composition;

wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 5 to about 120 Pascal seconds.

22. The disposable absorbent product of Claim 21, wherein the polyethylene oxide polymer has a weight average molecular weight that is between about 150,000 to about 10,000,000.

23. The disposable absorbent product of Claim 21, wherein the multicarboxylic acid has a total of carbon atoms that is between about 3 to about 30.

24. The disposable absorbent product of Claim 21, wherein the multicarboxylic acid is selected from the group consisting of malonic acid, citric acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, and mixtures thereof.

25. The disposable absorbent product of Claim 21, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between

about 20 weight percent to about 60 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 25 weight percent.

26. The disposable absorbent product of Claim 25, wherein the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 30 weight percent to about 50 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 30 weight percent to about 50 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 15 weight percent to about 20 weight percent.

27. The disposable absorbent product of Claim 21, wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 10 Pascal seconds to about 110 Pascal seconds.

28. The disposable absorbent product of Claim 27, wherein the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 15 Pascal seconds to about 100 Pascal seconds.

29. The disposable absorbent product of Claim 21, wherein the polyethylene oxide polymer has a weight average molecular weight that is between about 150,000 to about 10,000,000 and the polyethylene oxide polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, the aliphatic polyester polymer is present in the thermoplastic composition in a weight amount that is between about 20 weight percent to about 60 weight percent, and the multicarboxylic acid is present in the thermoplastic composition in a weight amount that is between about 10 weight percent to about 25 weight percent and is selected

5 from the group consisting of malonic acid, citric acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, and mixtures thereof, and the thermoplastic composition exhibits an Apparent Viscosity value at a temperature of about 190°C and a shear rate of about 1000 seconds<sup>-1</sup> that is between about 10 Pascal seconds to about 110 Pascal seconds.

10 30. The disposable absorbent product of Claim 21, wherein the aliphatic polyester polymer is selected from the group consisting of polylactides, a polybutylene succinate polymer, a polybutylene succinate-co-adipate polymer, a polycaprolactone polymer, a mixture of such polymers, or a copolymer of such polymers.

15 31. The disposable absorbent product of Claim 21, wherein the backsheet, the topsheet and the absorbent structure comprise fibers prepared from the thermoplastic composition.

32. The disposable absorbent product of Claim 21, wherein at least two of the backsheet, the topsheet and the absorbent structure comprise fibers prepared from the thermoplastic composition.

# INTERNATIONAL SEARCH REPORT

Int lional Application No

PCT/US 00/29756

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C08L71/02 C08L67/04 C08L67/04 C08K5/092 D01F6/94  
D01F6/92 A61F13/15 A61L15/22 A61L15/62

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C08L C08K D01F A61F A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99 32559 A (KIMBERLY CLARK CO) 1 July 1999 (1999-07-01) the whole document	1-32
A	WO 99 27008 A (KIMBERLY CLARK CO) 3 June 1999 (1999-06-03) the whole document	1-32
A	WO 98 29493 A (KIMBERLY CLARK CO) 9 July 1998 (1998-07-09) the whole document	1-32

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/29756

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WO 9829493 A	09-07-1998	AU 5904398 A BR 9714244 A CN 1247548 A EP 0951504 A HU 0000723 A NO 993219 A PL 334612 A SK 87599 A TR 9901501 T	31-07-1998 18-04-2000 15-03-2000 27-10-1999 28-07-2000 29-06-1999 13-03-2000 16-05-2000 21-09-1999